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# GRATANKO : GRANULES OF OIL PALM EMPTY FRUIT BUNCH AS A BIOMASS BASED ENERGY IN INDONESIA

**Sahal Sabilil Muttaqin[1], Cahaya Prautama[2]**, Saefullah Thaher[3], Namira Nur Arfa[1], Sigit Arif Anggoro[4], Irfan Dwidya Prijambada[2]

[1]*Biology, Faculty of Biology, Universitas Gadjah Mada, Yogyakarta, Indonesia*
[2]*Agricultural Microbiology, Faculty of Agricultural, Universitas Gadjah Mada, Yogyakarta, Indonesia*
[3]*Chemical Engineering, Faculty of Engineering, Universitas Gadjah Mada, Yogyakarta, Indonesia*
[4]*Physics Engineering, Faculty of Engineering, Universitas Gadjah Mada, Yogyakarta, Indonesia*
Corresponding author's email: sahal.sabilil.m@mail.ugm.ac.id

## ABSTRACT

Oil palm empty fruit bunches (*Elaeis guineensis*) are a product of the rest of the palm oil processing industry. It has a potential as biomass fuel in the form of granules because has a carbon content that can be burned. The Implementation of the study was to prove that the oil palm empty bunches can be processed into granules, knowing the characteristics of granules oil palm empty fruit bunches in the combustion process is optimized, and calculate the amount of energy (Cal / g) resulting from the burning of oil palm fruit bunches empty grain. The research method used follows steps such as collecting and elication, milling, granulation, and analysis of characteristics of granules such as moisture content, ash and volatile content, specific gravity, calorific value, and fixed carbon. The results showed that the oil palm empty fruit bunches can be formed into granules and have the best quality at a concentration of 5% to the characteristics of moisture content (45.13%), ash content (13.903%), volatile value (43.939%), density (0.886 g / cm$^3$), the calorific value (4581.448 Cal /g),) and fixed carbon (13.563%). The ash and volatile value greatly affect the results of the calorific value.

**Keywords:** calorific value, carbon, palm oil

## 1. INTRODUCTION

Indonesia is an agricultural country that produced many underutilized agricultural wastes. Agricultural waste is an alternative energy source that is abundant with relatively large energy content so that it can be used as biomass (Sulistyanto 2006). Biomass for energy has several advantages such as renewable, can be stored, abundant and environmentally friendly (Yoshikawa 2005). Biomass is one of the mainstay of energy sources to produce energy efficiency in the world (Yokoyama 2008). Unfortunately, the use of biomass for energy also has limitations such as the moisture and ash content that are relatively high. Providing the lower energy content is lower than fossil fuels (Hermawati 2013). The potential of biomass for energy in this sector is largely which can be derived from plant waste or waste production of plantation crops such as oil palm, sugarcane, and coconut. The waste from oil palm plantations is a shell, empty fruit bunches, fibers, black liquor, and liquid waste (Hermawati 2013).

Oil palm empty fruit bunches are one of the dregs of palm oil processing which are often less than optimal utilization. This is based on the data from Wijono which says the percentage of oil palm empty fruit bunches (EFB) to the fresh fruit bunches around 21%, so the potential of oil palm empty fruit bunches reached about 22.75 million tonnes per year with a water content of 60%, or about 9.1 Million tons of dry empty fruit bunches (EFB) waste is solid waste that is large enough, which is about 6 million tons, but its use is still limited (Wijono 2004). The utilization of oil palm empty fruit bunches is limited to being burned and then used as fertilizer (Directorate General PPHP 2006). whereas oil palm empty fruit bunches has an energy content in the carbon bonds, so we have innovation to package it into granules form. The granulation has a tendency to increase the flow of powder by forming it into balls or aggregates in the same form (Pratiwi 2008). The results of the research obtained have the potential to support the development of renewable energy in Indonesia according to the national energy policy in Indonesian Government Regulation number 79 of 2014. This regulation mandates the percentage of utilization of renewable energy in the national energy at least from 23% in 2025 to 31% in 2050. The development of biomass-based energy can be a solution to waste problems while supporting energy development in remote areas. (Sugiyono et al. 2015). Therefore, this Gratanko (abbreviation of granules of oil palm empty fruit bunch in Indonesian language) is one alternative biomass-based energy development nationwide.

## 2. MATERIALS AND METHODS

### a. Collection and elicitation of oil palm empty fruit bunch

This process is carried out by collected 100 kg of oil palm empty fruit bunches from palm oil plantations in Jambi Province. Then, it is enumerated to facilitate the grinding process.

### b. Milling the empty fruit bunch

This process was carried out at the Conversion Laboratory of Biomaterials Chemistry, Faculty of Forestry, Universitas Gadjah Mada. Milling was done by grinding the palm bunches using the grinder (grinder). It contained through three stages of sifting at 10 , 40, and 60 mess. This Process aims to obtain smooth EFD power with the size of 60 mess.

### c. Formation of granules (Granulation)

Granulation was conducted at the Laboratory of Food and Bioprocess Engineering, Faculty of Engineering, Universitas Gadjah Mada. The granulation process is carried out by grinded the oil palm empty fruit bunches until smooth in powder form, then added starch glue with different concentrations of 5%, 7.5% and 10% which are useful to combine the powder to form granules. The granules was formed using granulator. Then, the granules was dried for 2-3 days by oven.

**d. Characteristics of granules**

The testing was conducted at the Laboratory of Wood Biomass Energy, Faculty of Forestry, Universitas Gadjah Mada. The basic characteristics included moisture content, ash and volatile test, density test, combustion heating value, and carbon bonded.

**2.4.1. Moisture content analysis**

Moisture content analysis of the granules, firstly the crucible is measured, then granules are inserted into the crucible. the next step, both were put into the oven with a temperature of 110 °C. then cooled and weighed and repeated five times, then calculated by the formula was conducted according to the method of BS 1016 section 104.1 (British Standards Institution 1999).

**2.4.2. The ash and volatile analysis**

The ash and volatile analysis were performed according to the method of BS 1016 section 104.4 and section 104.3, respectively (British Standards Institution 1999). The ash and volatile analysis of the granules, firstly the crucible is measured, then granules and crucible are inserted into the furnace. granules are inserted into the furnace, the furnace is set at 550 °C for 30 minutes, then raised at 815 °C for 75 minutes. then cooled and weighed and repeated five times, then calculated by the formula was conducted according to the method of BS 1016 section 104.4 and 104.3.

**2.4.3. The specific gravity analysis**

Specific gravity tests was carried out used mass and volume measuring devices with Archimedes' legal principles and parfirin waxing. Calculated the difference between the initial fluid and the lost fluid.

**2.4.4. The calorific value of combustion**

Before sample testing, standardization of calorimeter bombs was carried out to determine whether the equipment was still good or not. The sample used is standard Benzoic Acid which has known heating value. The value of heat capacity is obtained from standard calorimeter bombs using Benzoic Acid samples. Testing the combustion calorific value was done by using a set of brand PARR bomb calorimeter apparatus and analytical balance. The calorific value of combustion was calculated by the method BS 1016 section 105 ((British Standards Institution 1992).

**2.4.5. Fixed carbon calculation**

The fixed carbon was calculated according to the SNI 13.3479 1994 as showed in following formula. Fixed carbon (FC) = 100% - (Volatile matter + Ash content + Moisture content) (Indonesian National Standard 1994).

**2.4.6 Data Analysis**

All data were analyzed using SPSS 16.0 and Ri286 3.3.0 software. The research method used was a completely randomized design with three replications of each treatment.

## 3. RESULTS AND DISCUSSION

Based on research that has been done by measuring various parameters such as moisture content, ash and volatile content, specific gravity, calorific value, and fixed carbon, then the data obtained in table 1.

**Table 1 : Results of granules analysis**

| Parameter | Concentration of glue (%) | | |
|---|---|---|---|
| | 5 | 7.5 | 10 |
| Moisture content (%) | 34.23 | 42.56 | 45.13 |
| Ash content (%) | 10.488 | 13.523 | 13.903 |
| Volatile compounds (%) | 43.929 | 35.261 | 28.880 |
| Specific gravity ($g/cm^3$) | 0.867 | 0.883 | 0.886 |
| Fixed carbon (%) | 11.357 | 8.660 | 12.086 |
| Calorie (cal/g) | 4581.488 | 4473.398 | 4452.610 |

### 3.1. Moisture content

In this study, it was found that in granules with variable concentrations of 5%, 7.5%, 10% each had value of moisture content of 34.23, 42.56, and 45.13 %. In this study the water content of the three tests was very high when compared with SNI 01-6235-2000 about bamboo charcoal where the water content produced was up to 8%, but this research carried out renewable innovations. This is due to the amount of glue used and the drying time which is only about 18 hours from expectations for 3 days (Putra et al. 2013), so that the water content contained in the granules has not evaporated completely and this is in accordance with the treatment studies conducted resulting in each treatment do not show significant difference.

### 3.2. Ash content

In this study, it was found that in granules with variable concentrations of 5%, 7.5%, 10% each had value of ash content of 10.488, 13.523, and 13.903 %. According to Isa et al. (2012) states that the greater the value of ash content can affect the lower the quality of biomass briquettes, because ash content can reduce the calorific value. Additionally, high levels of ash were able to induce the formation of slag, causing a decrease in the efficiency of combustion (El Basam and Maegaard 2004). Based on observations of three different experiments have real significance. In this results the 7.5% variable had higher ash content than other variables, see figure 1.

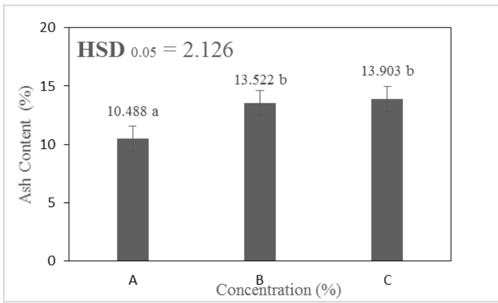


**Figure 1 : Ash content of granules A = 5 %, B = 7.5 %, C =10 %**

### 3.3. Levels of volatile compounds

In this study, it was found that in granules with variable concentrations of 5%, 7.5%, 10% each had levels of volatile compound of 43.929, 35.261, and 28.88 %. In this results the 5% variable had higher ash content than other variables, see figure 2. The higher the volatile matter content of a briquette can easier it is on fire, thus burning quicker (Subroto 2007). this result is lower than research on manufacture biomass pellets oil palm empty fruit bunches have high levels of volatile compounds, namely 70 677% (Sutapa et al. 2015), but the content of volatile compounds granules larger than fiber and shells (Raharjo 2012).

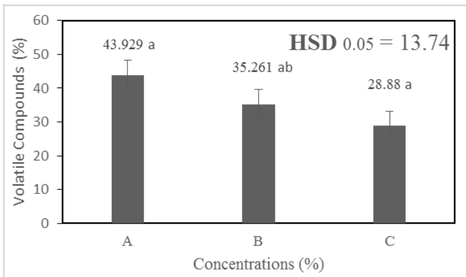


**Figure 2 : Levels of volatile compounds of granules A = 5 %, B = 7.5 % and C =10 %**

### 3.4. Levels of specific gravity

In this study, it was found that in granules with variable concentrations of 5%, 7.5%, 10% each had levels of specific gravity of 0.867, 0.883, and 0.886 g/cm$^3$. Specific gravity testing can affect the high of calorific value. High specific gravity values are in line with high of calorific value (Burhanuddin 2006). High-low density types are determined by the pressure used in the process of densification (Demirbas 1999) while the basis of research Sutapa et al. (2015) showed that the density pellets of palm oil at 1.167 g / cm3, this is due to the fact that granules are not pressed so that the value of granules is not as high as a pellet.

### 3.5. Fixed carbon

In this study, it was found that in granules with variable concentrations of 5%, 7.5%, 10% each had levels of fixed carbon of 11.357, 8.660, and 12.086 %. Levels of fixed carbon to high will cause the high calorific value of combustion (Hendra 2007), the observations are not their real significance of each treatment, while those that affect the amount of the bound carbon content depends on the water content that is if the higher the water content causes the lower carbon to be bound (Putra et al. 2013).

### 3.6. Calorific levels

In this study, it was found that in granules with variable concentrations of 5%, 7.5%, 10% each had levels of calorific value of 4581.488, 4473.398, and 4452.610 Cal/g. Based on the results of observations show that effective concentrations granules to be used as fuel biomass-based energy is a concentration of 5% is 4581,488 Cal / g. This is evident from the low levels of ash waste generated indicating the combustion process low and high levels of volatile compounds which indicates the speed of the combustion process faster then, from observations to decide levels of concentration of glue 5% have the best quality of the test results as compared to other concentrations. These findings are consistent with research conducted by Budiyanto et.al. (2009), namely briquettes oil palm empty fruit bunches without authoring achieve optimal quality in treatment, concentration of 5% has a calorific value of 4,272 kcal / kg, biomass biobriquettes not easily damaged / defective and superior to treatment different from other concentration. Meanwhile, according to the Director General of Mineral and Coal rule number: 515.K / 32 / DJB / 2011 on Formula for Pricing Benchmark Coal , there are eight major cell types and turns Gratanko has a higher heat than coal types Jorong J-1 and Ecocoal IE 4400 Cal / g and 4200 Cal / g.

## 4. CONCLUSIONS

Oil palm empty fruit bunches (*E. guineensis*) can be used as biomass in the form of granules. The granules have the best quality at a concentration of 5% to the characteristics of adhesive moisture content (45.13%), specific gravity (0.886 g / cm3), the calorific value (4581.448 Cal / g), the value of volatile compounds (43.939%), ash (13.903 %) and fixed carbon (13.563%).

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## 6. REFERENCES

British Standards Institution. (1999). Methods for Analysis and Testing of Coal and Coke. British Standards Institution (BSI).

British Standards Institution. (1992). Methods for Analysis and Testing of Coal and Coke. British Standards Institution (BSI).

Budiyanto, Bosman S., Andwini P. (2009). Study of Utilization of Oil Palm Empty Bunches (OPEFB) for Biobriquette Making., National Seminar on Western Indonesian BKS-PTN, Serang

Burhanuddin, Violet. (2006). "The Physical and Chemical Characteristics of Charcoal Briquettes in Ethnic Bamboo Stump Waste (Dendrocalamus asper Schult) from Loksado Village, Kab. Hulu Sunga Selatan"., Proceedings of the Banjarbaru Mapeki Ix National Seminar, 400

Demirbas A. (1999). “Properties of charcoal derived from hazelnut shell and the production of briquettes using pyrolitic oil. Energy”., 24, 141-150.

Directorate General PPHP. (2006) . Guidelines for Waste Reduction Palm Oil. Sub-Directorate of Environmental Management. Directorate of Agricultural Product Processing.

El Basam N, and Maegaard, P. (2004) . Integrated renewable energy on rural communities planning guidelines, technologies and applications., Elsevier, Amsterdam.

Hendra, D. (2007). Manufacture of Charcoal Briquettes from a Mixture of Wood, Bamboo, Coconut Fiber and Coconut Shell as Alternative Energy Sources., Research Report, Forest Products Research Center, Forestry Research and Development Agency, Bogor

Hermawati, W. (2013). Biomass Resources: Neglected Indonesia's Energy Potential., IPB Press, Jakarta.

Indonesian National Standard. (1994). Procedures for managing waste in settlements. National Standardization Agency

Isa,I , H. Lukman, dan I. H. Arif. (2012). Charcoal Briquettes and Active Charcoal from Corn Cobs Waste., Chemistry education, FMIPA Gorontalo State University

Pratiwi, N.K. (2008). Characterization of floating granule preparations with controlled release system using pragelatinization of propionate cassava starch as forming matrix., FMIPA UI, Jakarta

Putra, H.P., Lukman H., Yebi Y., Dianty A.K. (2013). “Study of the quality of briquettes from oil palm empty bunches with rice waste adhesive”. Journal of Environmental Science and Technology., 5 (1), 27-35.

Raharjo, S. (2012). “Thermogravimetric analysis on palm solid waste and its conversion potential as fuel gas”., J. T. Ling, 9 (2), 115 – 120.

Regulation of the Director General of Mineral and Coal Republic of Indonesia number: **515.K / 32 / DJB /2011** about the Formula for Determining Coal Benchmark Prices

Subroto. (2007). "Characteristics of burning wood and straw charcoal briquettes"., J. Media Machines, 8 (1), 10-16

Sugiyono, A. Anindhita, M. S. Budoyo, Adiarso. (2015) . Outlook Energy Indonesia., BPPT, Jakarta.

Sulistyanto, A. (2006). "Characteristics of biobriquette combustion of coal and coconut fiber mixtures. J. Media Machines. ", 7 (2)., 77-84.

Sutapa. J.P.G., Ragil W., Denny I., Anindya H.H. (2015). Converting Oil Palm Empty Fruit Bunches to High Quality Pellet., Research Poster Publications, Universitas Gadjah Mada, Yogyakarta

Yoshikawa,S. (2005). New Energy Research for Sustainable Environment. ASTW 8th (ASEAN Science & Technology Week) Manila, Filipina.

Yokoyama, S. (2008). Asian Biomass Handbook., The Japan Institute of Energy, Japan.

Wijono, A. (2014). PLTU for Oil Palm Empty Fruit Bunch Biomass Feasibility Study and Environmental Impact. RAPI XIII National Symposium FT UMS.